

Myanmar Institute for Integrated Development

Inle Lake Young Ambassadors Programme  
(September 2019 – March 2020)  
Hotspot Journal



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## Executive Summary

The Inle Lake Young Ambassador Programme was launched in October 2019 and closed in March 2020. Ten young people from Inle Lake region attended trainings, exposure visits and lectures by experts about the environmental issues of Inle Lake. They led their own research projects and engaged with local communities, raising awareness and collecting the villagers' voices and experiences. Based on their observations, they identified 5 key issues in Inle Lake region and here offer field-based suggestions.

### Erosion and Sedimentation Processes

One of the main risks for Inle Lake is sedimentation, linked to erosion in the surrounding hills. During their field work, the Young Ambassadors measured the depth of the lake: 10' maximum and 7'1" on average in October 2019; 6'8" maximum and 4'2" on average in March 2020. Suggestions to mitigate erosion includes promotion of Community Forests; developing community-led check dams; supporting agriculture that preserve the soil and reduce erosion: better management of biomass, contour farming, soil conservation-friendly crops.

### The Fishing Sector Crisis

In the last twenty years, fish population has decreased markedly; the size of the catches has dropped; endemic species have become rare. This has had major consequences on fishermen's livelihood. This has also had a major impact local people's culture and is fostering tensions. In such a context, the Young Ambassadors and MIID recommends setting up a systematic monitoring system of the fish population; promoting wider environmental improvements which may have an indirect positive effect on the local fauna; supporting fishermen to diversify their activities, provide ways for communities to restrict unsustainable practices and promote provision of ecosystem services by lake inhabitants.

### Agriculture-Related Pollution

Inle Lake iconic floating agriculture is a very intensive form of agriculture, which environmental impacts are not clearly documented. Our research shows that a floating farm is approximately 1.5 acre and harvests on average 26,800 kg of tomatoes per year. In terms of impact, farmers use on average 17.4 bags of fertilizer/acre/farming season, spend around 800,000 MMK for pesticides, and half of them suffer from health issues reportedly linked to the use of chemical products. Our interviews highlight the economic mechanisms: the massive use of chemical inputs is due to decreasing tomato price and farmers caught in a debt trap. Such issues must be addressed to solve Inle Lake environmental challenges. The Young Ambassadors suggest setting up clear information about use of chemical; promote use of natural fertilizer and bio-pesticides; promote shift to Good Agriculture Practices through a better linkage to the tourism sector as well as by crop diversification.

### Water and Sanitation

It appears that only one third of our interviewees has a septic tank, while one third discharges faeces and urine directly into the lake. While most villagers used to drink water from the lake in the past, they have changed their behaviour: nowadays, half of them consume purified water, and only 3% still drink lake water. Despite such an improvement, risky practices still linger: 12% of respondents rinse their food in lake water, while 61% bathe in the lake next to their doorsteps. This is all the riskier as the water is contaminated by human faeces: after collecting 20 water samples from 18 villages in March 2020, we established that 100% of them were contaminated by *E. Coli* bacteria. In such a context, the Young Ambassadors suggest strengthening and complementing hygiene education campaigns; addressing technical challenges through innovative but simple technologies; setting up a strong financial incentive and sanction scheme to encourage the acquisition of proper water sanitation systems.

### Solid Waste Management

In spite of efforts by CSOs and local private sector, solid waste management in Inle Lake region remains a challenge, which can impact the region's ecosystem, landscapes and reputation, as well as its inhabitants'

health. In order to improve the situation, there should be a campaign to raise awareness in waste reduction. Reusable bags and bottles should be encouraged, one-time use plastic bags should be discouraged. It is also recommended to transform waste into a commodity that communities can trade for profit i.e. payment for ecosystem services. The Inle region should also connect to wider waste management initiatives, such as the whole Taunggyi district, in order to pool more resources.

## Introduction

The Myanmar Institute for Integrated Development (MIID) is a Myanmar-based research and development organisation formed by a group of international and Myanmar senior development practitioners, academics, and researchers. MIID, initially IID-Myanmar, was formed in 2010 and is registered with the Ministry of National Planning and Economic Development and holds MOU with Ministry of Natural Resources and Environmental Conservation (MONREC). MIID's focus is on inclusive socioeconomic development and poverty alleviation in rural areas of Myanmar, including sustainable natural resources management, environmental conservation and climate change adaptation, agriculture, food security and nutrition, support to establishing SMEs, heritage tourism, good governance and social protection. MIID specialises in ethnic minority communities in the upland areas of Myanmar, suffering from decades of isolation, degradation of the natural resource base and armed conflicts. The Institute maintains a broad network of Myanmar specialists. MIID'S senior staff, nominated to oversee this project have work experience in Myanmar spanning over more than 20 years, involving high level policy contact and development programmes for ethnic minority groups living in upland areas.

MIID has been a key development stakeholder in the Inle (Inlay) region since 2011. The institute prepared the 2010 - 2025 *Inlay Lake Conservation Project, A Plan for the Future* (IID, 2012), as well as the *Tourism Destination Management Plan for the Inlay Lake Region 2014 – 2019* (MIID, 2014). MIID has also assisted with the preparation of 5-year development plans for the Pa-O and Danu Self-Administered Zones, located in the lake watershed.

In 2018, MIID was contracted by the UNDP to jointly implement the project “Strengthening the Inlay Lake Management Authority (ILMA), Development & Conservation”, funded by the Norwegian Ministry of Foreign Affairs. The project's rationale is to prepare the action of the ILMA, a coordination body MIID has been advocating for since 2012 (IID, 2012: ii). Among other actions, MIID initiated an innovative “Inlay Lake Ambassador Project” (ILAP) to connect the ILMA to the communities.

The ILAP was officially launched in August 2019. More than 50 young people applied to the program, and 10 were selected based on their motivation and their commitment to Inle environment, while representing the ethnic diversity of the area as much as possible. The project comprised three main stages:

- From October 17 to November 6, 2019, the Inle Lake Young Ambassadors attended an intensive training about Inle Lake environmental condition, challenges and potential solutions.
- From November 28 to December 11, 2019, the Inle Lake Young Ambassadors led their own research on the lake: one group focused on the socio-economic situation of the floating gardens farmers, while another dealt with the water and sanitation issue in the stilt villages on the lake.
- From December 18, 2019 to March 17, 2020, the Young Ambassadors led an ambitious outreach campaign throughout the watershed area, from Aungban in the north to Samkar in the south, and from Kyar Toon in the west to Lwe Khaw in the east. They held exhibitions in nine markets and provided in-depth community talks in six villages, reaching out to thousands of people (figure 1).

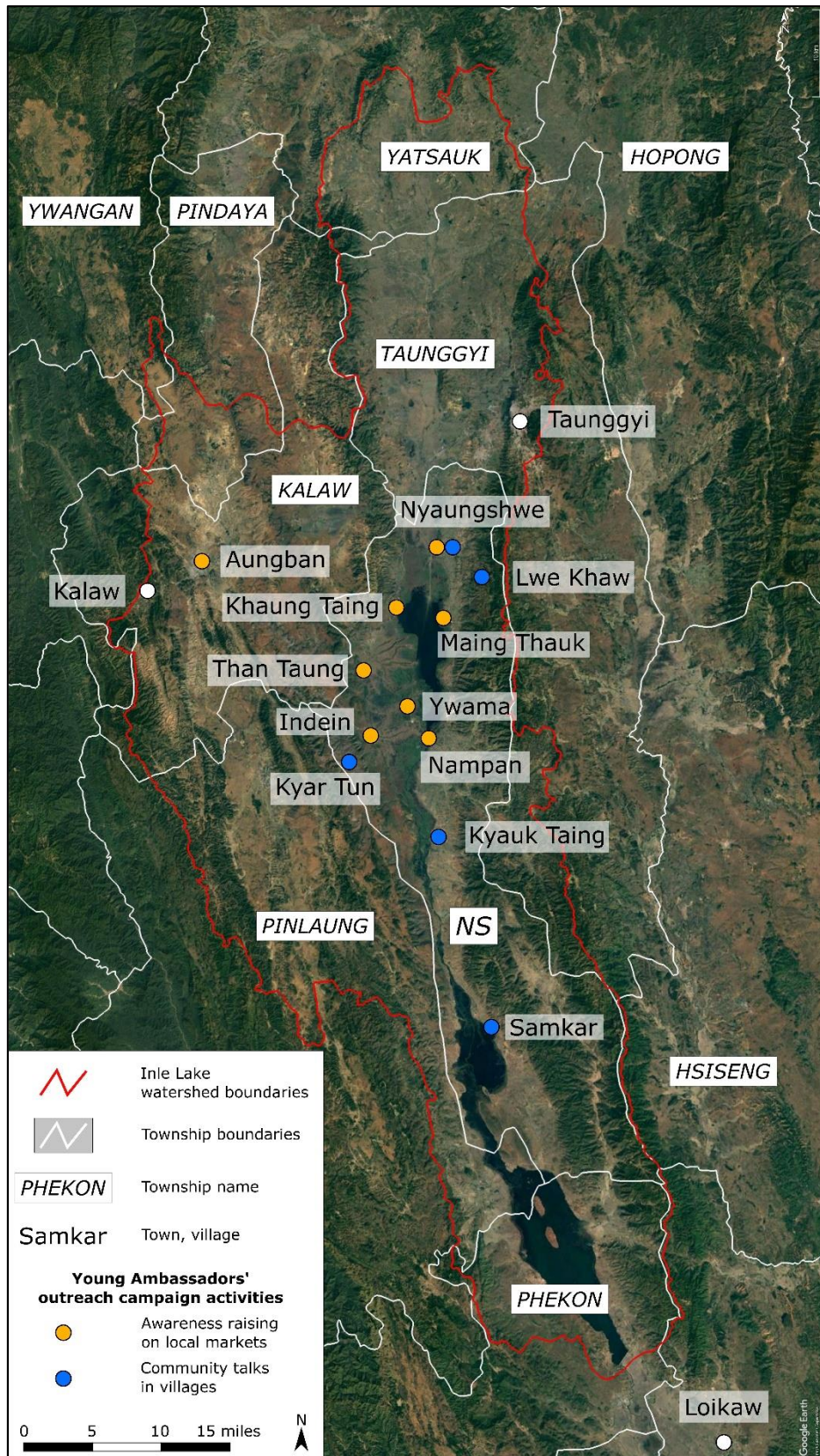


Figure 1: Map of Inle Lake Young Ambassadors' Outreach Activities.

Throughout those months, the Inle Lake Young Ambassadors attended trainings and talks by guest lecturers; travelled extensively throughout the region leading their own scientific campaigns; met with villagers who voiced their concerns and discussed potential solutions with national and international experts. Despite their young age, they are stakeholders with high-potential, whose experience and knowledge may be valuable for further activities of the ILMA or other development organization.

This hotspot journal deals with five main issues of Inle Lake:

- 1) Erosion and sedimentation processes
- 2) The fishing sector crisis
- 3) Agriculture-related pollution
- 4) Water and sanitation issues
- 5) Solid waste management

Those are not the only threats to the Inle Lake environment, but those which appeared the most prominent to the Young Ambassadors, the ones they could grasp best, and for which practical solutions appeared clearly in demand. For each of those topics, this document is a synthesis of research, activities and findings, as well as of possible solutions that might be implemented in the future.

## 1. Erosion and Sedimentation Processes

### 1.1. An Assessment of the Problem

The decreasing depth of Inle Lake in the last decades can be ascribed to sedimentation mostly from erosion in the watershed hills. Agriculture and deforestation are two important causes of the erosion. Our team researched the sedimentation issues and investigated the situation on the lake itself and these are described below in detail. The Inle Lake sedimentation issues can be abated by reforestation through community forestry, check dams and changes in agriculture practices that preserve soil quality.

In 1918, British researcher N. Annandale reported that the lake depth was 20 feet in the rainy season and 12 feet in dry season. Since then, some surveys as well as government data points to a clear depth decrease: the depth of approximately 10 feet in the rainy season and 6 feet in the dry season.<sup>1</sup> However, recent reports still quote the lake depth as being 20 feet in rainy season and 12 feet in dry season. Such ambiguity can have significant consequences in terms on decision-making and environmental management.

During our activities, our MIID specialists and the Inle Lake Young Ambassadors examined first-hand and documented the depth of the lake through two depth measurement campaigns. The first took place on October 22, 2019 and the second was March 8, 2020. In October, near the end of the rainy season the average depth was 7'1"; the minimum depth was 3'10", and the maximum depth (in the southeast part of the lake, near Tha Le Oo village) was only 10' (figure 2).<sup>2</sup> There were some discrepancies between the depth indicated on mile posts and actual depth: for instance, on the post 7 miles from Nyaungshwe to Phaung Daw Oo, the actual depth was 1.5' more shallow than the indications painted on the post. More comprehensive campaigns are needed, but our work strongly suggests that a lake depth of 20 feet in the rainy season is not realistic.

The second campaign measured the same 27 sites as the first and there was a clear decrease in depth: the average depth was 4'2" (previously 7'1"); the minimum depth was a concerning 1' (previously 3'10"), and the maximum depth was 6'8" (previously 10'). Several villages had no more than 1' of water in their canals, and

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<sup>1</sup> MoECA, 2014; Nyaungshwe Irrigation Department. ; Saw Yu May, 2007; Furuichi, 2008; Michalon et al., 2019.

<sup>2</sup> The research team of Inle Lake Ambassadors and MIID's Scientific Advisor visited sites along a grid of 27 points pre-positioned by GPS. The depth of each point was measured by using a graduated bamboo pole. Out of the 27 points visited, the average depth was 7'1"; the minimum depth was 3'10", and the maximum depth (in the southeast part of the lake, near Tha Le Oo village) was only 10' (figure 2).

boat drivers sometimes had to push their launches. Such figures are all the more concerning as they were measured in early March 2020, two month and a half before any significant rainfall. It is therefore highly probable that the 2020 dry season will be a difficult one for Inle Lake and its inhabitants.

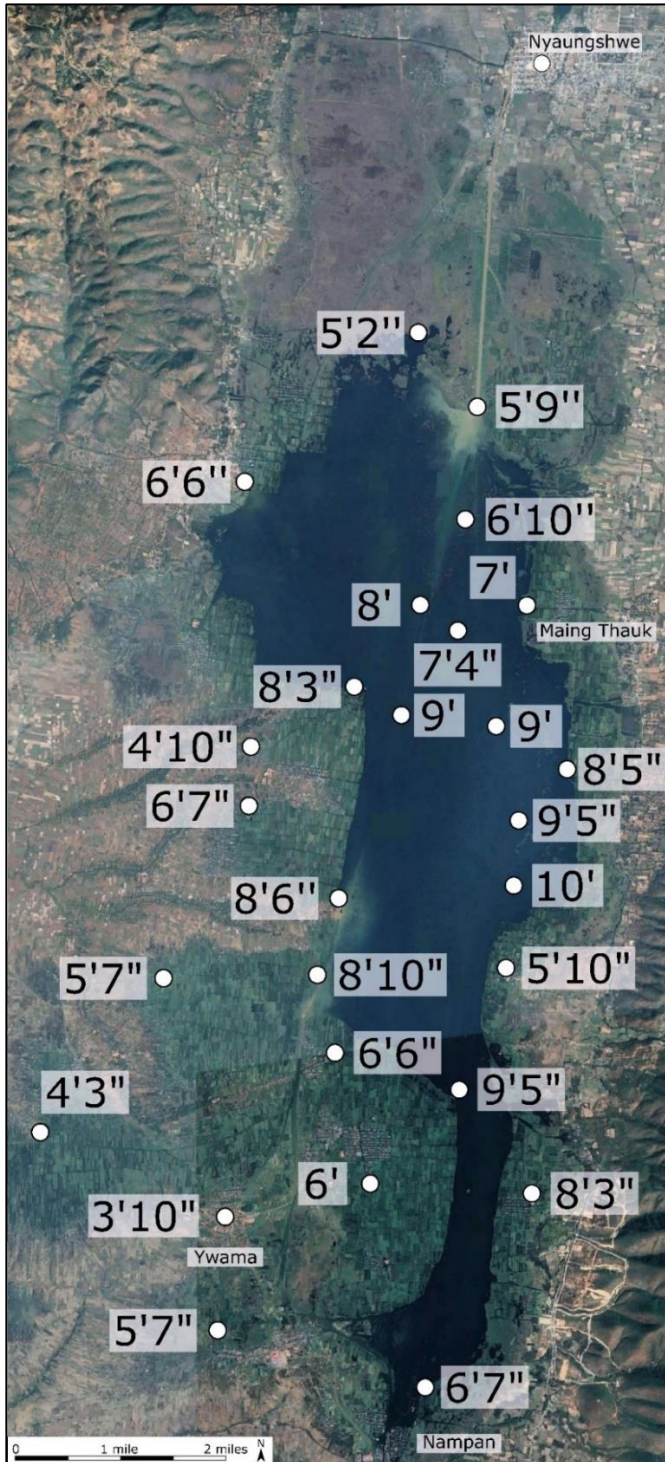


Figure 2: Inle Lake depth in October 2020 (rainy season).

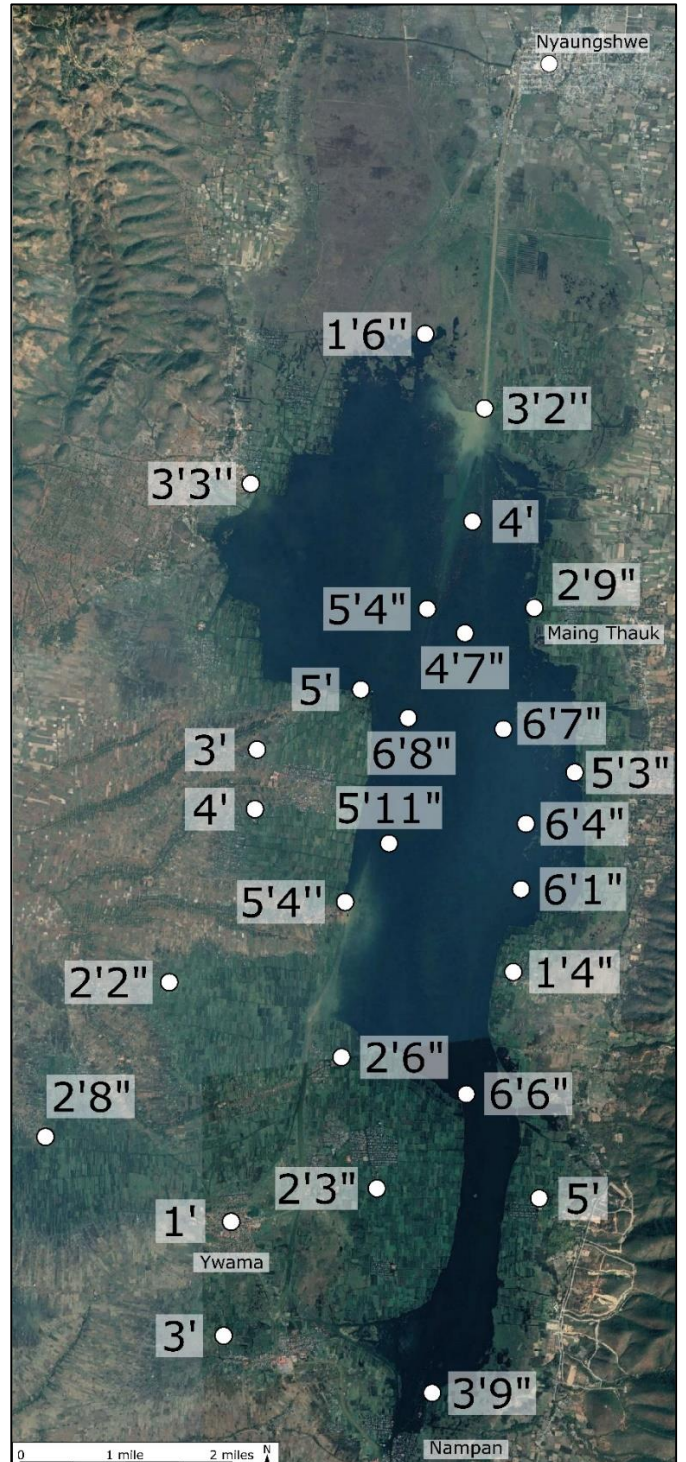


Figure 3: Inle Lake depth in March 2020 (dry season).



The decreasing depth of Inle Lake in the last decades can be ascribed to sedimentation, which is itself due to erosion in the hills. The latter process could be observed quite clearly during our exposure trips, in the form of deep gullies (figure 4).



Figure 4: Erosion gully on the road from Nyaungshwe to Lwe Khaw. Picture: Inle Lake Young Ambassadors.

Erosion usually results from deforestation and ill-adapted agriculture practices and soil management. In the Inle Lake watershed, clearing forest for agriculture, often through burning, has often been singled out as the main driver of land degradation. Some agriculture in the area is rotational and some is fixed and both can include potentially harmful practices that can increase erosion, such as the recurrent burning of the fields after harvest (figure 5).



Figure 5: Field burning in Lwe Khaw area. Picture: Inle Lake Young Ambassadors.

## 1.2. Erosion and Sedimentation: Towards Some Solutions

Based on our research and experience, the Young Ambassadors and MIID would recommend reducing erosion through the following: reforestation and forest protection through promotion of community forestry, development of check dams and support to less risky agriculture practices. Some of them are not new to the region but might be expanded or transformed.

### 1.2.1. Promotion of Community Forests

Community Forests (CF) are an efficient way to promote forest conservation. Results can be impressive: in Nyaung Le Pin village, south of Samkar Lake, the forest cover of the local hill has dramatically improved in the last few years (figure 6). The forest has become a shared resource which benefits everyone, especially the poorer villagers, who have special rights to chop off trees to build their houses. The local community informed us that their success in CF was in large part due to the following:

- Strong leadership and a strong community structure are important for successful CF. The power relations, the micro-politics at a village scale are therefore a key feature which have to be taken into account.
- The villagers who used to earn their livings solely from the forest had to diversify to other activities. Any CF plan should therefore come along with strong, credible alternatives and incentives for part of the community.
- Support from government line departments is key: it provides legitimacy to the project and gives legal weight to the deforestation ban enforcement. The community emphasized the importance of early support, right from the inception of the project.

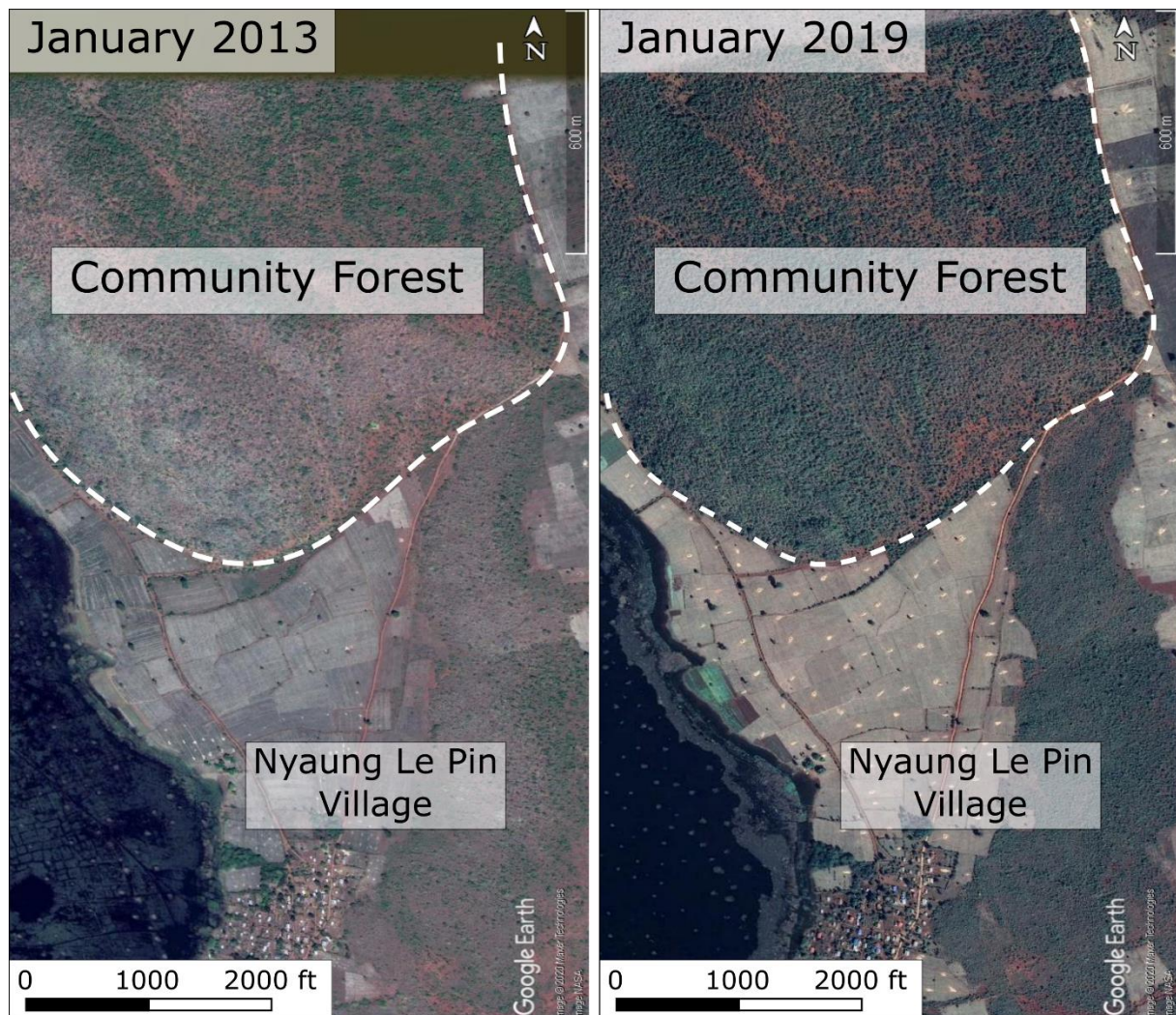


Figure 6: The benefits of community forest in Nyaung Le Pin region between 2013 and 2019.  
Source of the images: Google Earth Pro™.

### 1.2.2. Development of Check Dams

Check dams are very efficient to reduce sediment flows to the lake, while contributing to maintaining the fertility of the highlands. The Irrigation Department and Forestry Departments have already built numerous check dams throughout the watershed, with positive results. The Young Ambassadors could also notice small-scale, handmade check dams, made of wood and stones, even in one-foot-deep gullies. They would suggest leading community mapping of erosion and gully expansion at the village scale and train the villagers to build a network of small, hand-made check dams. This might be a cost-effective way to limit sedimentation flow right from the start, while giving ownership over those technical devices.

### 1.2.3. Supporting Agriculture Technique Changes

Development partners and line departments might support some important agriculture technique shifts:

Villagers may be informed about the pros and cons of burning their fields as well as bushes: not only does it make the soils prone to erosion, not only does it trigger health and atmospheric negative impacts, but it also represents a massive release of biomass into the atmosphere instead of agriculture use. Villagers may be trained to collect excess organic waste and either compost it or burn it in a controlled way called “slash and char”, which reduces gas and smoke emissions while keeping most of the biomass in the soil (figure 7).

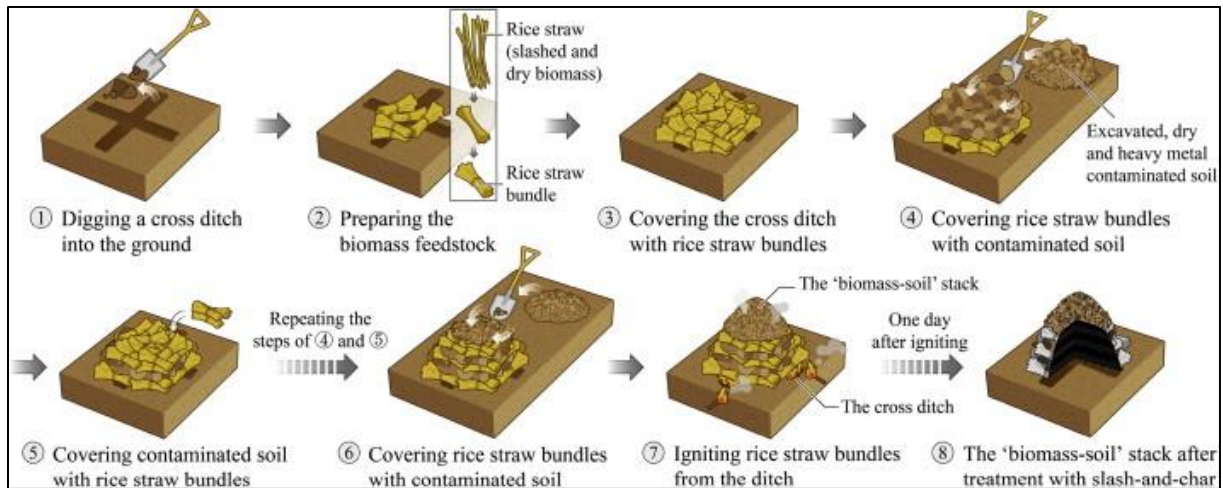


Figure 7: Slash-and-char: a very efficient way to burn organic waste while saving soil fertility. Source: Li-Qin Niu et al., 2015

Villagers may be trained to implement contour farming in their fields, a cost-effective technique that can dramatically mitigate soil erosion (Figure 8). The Young Ambassadors would recommend holding talks with villagers in order to assess more precisely current methods, and the practical, cultural constraints that prevent them from embracing contour farming. The government should provide technical and labour support in important watershed areas.

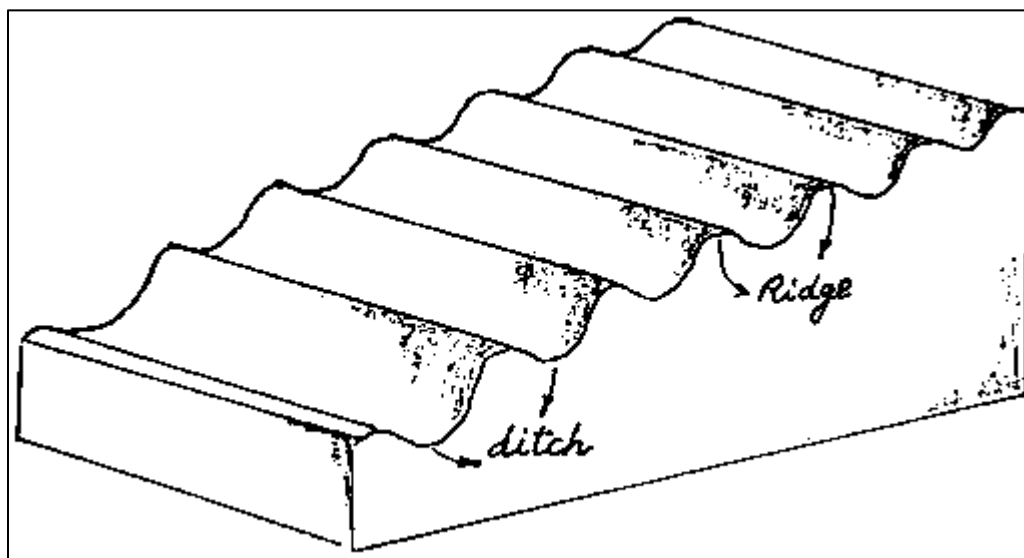


Figure 8: The principle of contour farming. Source: www.fao.org



Figure 9: Contour farming in the Let Maung Gwe Village Tract. Source: David Abrahamson

Several crops, such as onion, garlic, potato, ginger or curcuma, have especially high impacts in terms of erosion, because harvesting them means rooting them off, which disturbs the soils. A shift to agro-forestry (fruit trees, tea, coffee, etc.) might be a promising alternative: that would protect the soils better, while allowing farmers to preserve their incomes. However, such a move must be based on thorough socio-economic surveys, strong incentives and carefully designed product value chains in order to produce added value locally and secure good access to national as well as international markets.

## 2. The Fishing Sector Crisis

### 2.1. An Assessment of the Problem

The Inle Lake fishing sector has been one of the main blanks in the existing survey literature. There has been general research from a human perspective as well as zoological features.<sup>3</sup> However, there is insufficient analyse of the trend of the fish population in Inle Lake and status of each species' stock is unknown. This statistical blur is a significant hurdle to sound and sustainable management of the Inle fisheries. However, there is consensus that the fishing sector has been through a deep crisis since the early 2000s.

This appeared quite clearly during the interviews that Young Ambassadors held with fishermen during their research. Villagers reported a sharp drop in their catches: most of them used to catch an estimated 8.2 to 11.4 kg of fish per day in the 1990s; they nowadays catch only 1.6 to 3.2 kg. The size of fish has also decreased with fish catches weighing up to 1.6 kg in the past; nowadays, it takes 10 to 20 catches to reach that same amount. In addition, the species distribution has dramatically changed: endemic species have reportedly

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<sup>3</sup> Kano et al., 2016; Sein Sein Win et al., 2018; Research on zoological factors: FAO, 2003; Okamoto, 2012; Michalon, 2014

become so rare that they have reached the brink of extinction, while invasive species such as *Tilapia* now account for most of the catches.

The fishing sector crisis has deeply impacted the local social fabric: most fishermen have resorted to longer working hours, spending more and more time away from home, which impacts their family's welfare. They also adopt more efficient fishing gear, for modern fishing nets, which allow a short-term benefit, but accelerate the fish stock depletion.<sup>4</sup> Some have reportedly even switched to electric fishing, an illegal practice. Our interviewees reported high tensions and even violence between clandestine players and local communities. Some fishermen have given up fishing to work instead as daily laborers in farms or in local tomato warehouses, a shift that they described as a loss of identity and culture.

## 2.2. The Fishing Sector Crisis: Possible Solutions

The Inle Lake Young Ambassadors would like to put forward a few suggestions based on their research. The first step towards a sustainable management of the Inle fishery would be to thoroughly document its situation and trends, through a close follow-up of fish population by the Department of Fisheries or the Nature and Wildlife Conservation Division, Forest Department. This should include new surveys combined with an in-depth analysis and publicizing the results to local communities through fishermen associations, newspapers and social media.

The environmental challenges in Inle Lake region are integrated: the depletion of fish stock have been partly due to water pollution due to the hardships of the agriculture sector. Generally speaking, if some of the threats over Inle Lake recede (for example through a limited use of chemical products), those changes may also have a positive impact on the fish populations.

The development partners in the Inle Region may also take stock of the fishermen's livelihoods' deterioration and accompany them towards other – but still rewarding – professions. One may consider the possibility of transforming some vulnerable communities to become actors of their own environment: fishermen may get financial incentives to collect water hyacinth or waste, dredge some canals manually, or breed some endemic, high-value fish before releasing them into the lake. Such projects can help preserve the lake environment, provide an income to vulnerable populations, while strengthening their sense of ownership and responsibility communities have over the local environment.

## 3. Agriculture-related Pollution of Inle Lake

### 3.1. An Assessment of the Problem

Our research suggests that chemical fertilizer and pesticides are overused by many farmers. The amount of inputs is intensive and while farmers are aware of the harm, they are unaware of the appropriate levels of chemicals to provide. Chemical traders are also unaware of appropriate levels and guidance to the public is not widely available. The overuse of chemicals wastes money, pollutes the water and harms the lake ecosystem. Promoting the use of natural fertilizer, bio-pesticides, good agriculture practices and providing guidelines on use of chemicals could be helpful solutions to solving this problem.

Chemical pollution of water in Inle Lake is still poorly understood, data gaps remain and past research is not a reliable source for long-term monitoring and decision-making. Articles and reports are usually based on local water samplings, narrow timeframes, limited places and a reduced range of indicators. Hard data about water pollution, pesticides and heavy metals are still rare, although critical for the future of Inle and the health of its inhabitants.

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<sup>4</sup> The traditional conical net is called a *hsaung* in Myanmar Language ( ခေတ္တင်း )

A key sector related to water pollution is the iconic floating agriculture. MIID supported a team of five Young Inle Ambassadors from November 28 to December 5, 2019 to delve deeper into the socio-economic situation of floating agriculture on Inle Lake.<sup>5</sup> Throughout those seven days, the junior researchers visited 12 villages and led in-depth, semi-structured interviews with 52 people including 43 farmers, seven chemical fertilizer traders, one tomato broker and the Inle Lake Park Warden. Those interviews, led under the supervision of MIID's advisor, yielded several important findings that had seldom been described previously.

On average, our interviewees owned 1.58 acre of floating gardens.<sup>6</sup> Out of 43 farmers interviewed, 18 have increased the size of gardens they farmed. Those 18 farmers used to own one acre on average, and now own more than two acres, doubling their assets. However, Young Ambassadors' interviews also highlighted one key piece of information: farmers have increased the floating gardens mostly by reducing the space between them and adding more floating strips without increasing the overall area of coverage. Some others have increased their assets by buying, renting or inheriting already-existing floating gardens. The main conclusion is that floating gardens' area itself has not increased in the last two decades. This was confirmed through satellite images (figure 10): the orange line is the boundary between floating gardens and open water in 2004; the red line is the same boundary in 2017. Between those two dates, floating gardens expanded marginally at the expense of open water, which area just decreased 0.26% per year from 46.6 sq km in 2004 to 45.1 sq km in 2017.

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<sup>5</sup> Htun Naing Oo et al., 2010; May Lwin Oo et al., 2012; Michalon, 2014; Michalon et al., 2019

<sup>6</sup> In local units 950 *alan*. Based on farmers' statements and on measurements on high-definition satellite images 1 acre is equivalent to 600 *alan*.



Figure 10: Increase of floating garden length, but marginal area expansion: Inle Lake in 2004 and in 2017.  
Source of the images: Google Earth Pro™.



Farmers reported an average yield of 27,433 kg of produce per farming season<sup>7</sup>. This comes to approx. 37,000 Kg pr Ha which means that Inle Lake floating agriculture is extremely intensive, and features one of the highest yields in Southeast Asia<sup>8</sup>.

Chemical fertilizer use is very high on the lake. The *lowest* figure of chemical fertilizer use was 500kg per acre per farming season based on our interviews. If every farmer used such a quantity, that would amount to 4.2 million kg of fertilizers in the whole lake per farming season<sup>9</sup>.

The *average* figure collected was 853kg per acre per farming season<sup>10</sup>. That amount to 7.1 million kg of fertilizer in the whole lake per farming season.

Such findings highlight the very high consumption of chemical inputs in Inle Lake every year, part of which trickles down into the lake water and contributes to its eutrophication and to the spread of water hyacinth.

Understanding the volumes of pesticides is more complicated. The only figure that farmers could put forward is the budget they devote to pesticides: USD547/farm/farming season for conventional agriculture and USD500/farm/farming season for GAP agriculture.<sup>11</sup> This gap between two very different categories of agriculture might be an invitation to reinforce the implementation of good agriculture practice (GAP) standards in Inle Lake region.

Farmers estimated their investment required to grow their farm for one season:

Budget line	Average estimated budget (USD)
Chemical fertilizers	613
Chemical pesticides	547
Seeds	147
Labour	667
<b>Total</b>	<b>1,974</b>

Table 1: Average investment required in a floating farm on Inle Lake.

Those amounts should also include other expenses, such as the bamboo posts and sticks used in tomato farms, the boatloads of lake weeds and mud to fertilize the floating islands as well as the floating strips themselves. The investments committed by floating farmers appear to be very significant, which makes them vulnerable to crises and low prices.

The farmers we met were aware of the high quantities of chemical being used, and that it jeopardizes their environment and their health: 22 out of 43 respondents (51%) reported health issues related to the use of chemical products.

<sup>7</sup> Based on our interviews, 49% of the farmers plant tomatoes twice in a same year, while 51% of the farmers do only one farming season in their fields.

<sup>8</sup> This amounts to 46,000 kg/hectare per year, i.e more than double the average in Southeast Asia, which is 18,667 kg/hectare. Source : [www.fao.org](http://www.fao.org)

<sup>9</sup> The approximate area of active floating gardens on Inle Lake in 2014 was 8,200 acres (Michalon et al., 2019)

<sup>10</sup> Among our respondents, 7 farmers claimed to do Good Agriculture Practices (GAP). Their average chemical fertilizer consumption was reportedly 1.9 bag/100 alan/farming season, i.e. 11.4 bags/acre/farming season. Although this amount is lower than for conventional agriculture, it is only 1/3 lower, which might raise questions about the GAP sector in Inle. However, one should keep in mind that the demographic sample is too limited to be representative of the GAP farmers population.

<sup>11</sup> 82 lakh/farm/farming season for conventional agriculture and 7.5 lakh/farm/farming season for GAP agriculture

Most stated that they lack alternatives: with the emergence of new production areas in Central Myanmar, the improvement of communication and infrastructure, tomato prices have simultaneously dropped and become unstable. In order to maintain revenue, farmers feel they have to increase their yields and increase chemical inputs. Moreover, several farmers reported being in heavy debts towards local money lenders; in order to repay their debts, they must take higher risks to increase their yields.

Nowadays, the main challenge faced by the farmers is not environmental, but economic: when asked about the main hardships they face, the 43 interviewees gave the following responses:

Challenge of Floating Agriculture	Number of responses
Troubles to invest	26 (48 %)
Low tomato sale price	7 (13 %)
Lack of water	7 (13 %)
Weather degradation	4 (7.5 %)
Lack of manpower	3 (5.5 %)
Diseases	2 (4 %)
Quality and price of seeds	1 (2 %)
No problem	4 (7.5 %)
<b>Total</b>	<b>54 (100 %)</b>

Table 2: The main challenges of floating agriculture according to Inle farmers.

In other words, the Young Ambassadors' survey highlighted that the environmental crisis in Inle Lake region is closely linked to deep socio-economic transformations in Southern Shan State and in Myanmar. Therefore, environmental conservation must be considered in a holistic way, encompassing the very socio-economic fabric of the region. This approach is more complex, but at the same time, it can provide new leverage to protect the environment.

### 3.2. Agriculture-related Pollution in Inle Lake region: Suggested Solutions

The Young Ambassadors and MIID would like to share a few suggestions that might ultimately prove useful for the region's complex environment. Some have already been implemented, and the Young Ambassadors would suggest expanding those projects.

#### 3.2.1. Better Information on Chemical Inputs Use

The farmers we interviewed had very limited knowledge of the appropriate quantities of fertilizer and/or pesticide they should use on their floating gardens. Chemical products traders in Nyaungshwe as well were unable to give clear indications. Some guidelines are featured on the fertilizer bags we examined (usually 100kg of fertilizer per acre), but wide ambiguities remain: some farmers state that this amount of fertilizer actually refers to one application, and that they can do several applications per farming season; some others state that this threshold is only for dry land agriculture, and not relevant for floating agriculture, which reportedly demands more fertilizer. The same confusion applies for pesticides.

Facing this lagging ambiguity, the Young Ambassadors would recommend the following:

1. A maximum use guideline should be calculated, in collaboration with public research institutes, line departments and chemical product manufacturers. This guideline should be specific for the Inle region, adapted to local conditions (floating agriculture) and to the local popular crops (tomato, gourd, eggplant, etc.).
2. This guideline should be printed on posters and displayed very clearly in chemical input shops. It should also be printed on labels stuck on each fertilizer bag/pesticide bottle for sale. Some wholesalers may not

be willing to cooperate to such a system which may ultimately impact their sales. Abiding to those rules should therefore be considered as one of the conditions to get or renew a license to sell agricultural chemicals.

### 3.2.2. Promoting the Use of Natural Fertilizer

Based on their interviews, the Young Ambassadors would like to promote the use of natural fertilizer, which may be produced locally and for low prices.

As mentioned above, the local custom of burning fields and bushes during dry season is a loss of biomass into the atmosphere, which impacts the local climate and health. Therefore, we encourage local farmers to collect excess biomass and convert it into natural fertilizer, either through slash-and-char technique (see the Community Forestry section) or through composting, either by conventional techniques or by alternative, innovative techniques such as Bokashi.

There are some existing projects that could be expanded. In Khaung Taing village, there has been a plant transforming water hyacinth into natural fertilizer periodically. Such a project may deserve support from the local authorities. Likewise, the Dutch company Orgaworld is currently considering setting up a major composting plant in Southern Shan State, collecting organic waste from local towns, chicken farms and even water hyacinth from Inle Lake to convert them into natural fertilizer.

The development of natural fertilizer may help solve one of Inle Lake's major problems: spread of water hyacinth. Indeed, this floating vegetation can be composted which then could help farmers or even be sold. The Young Ambassadors would suggest setting up a collection system: trucks may be sent on a regular basis to certain points, and local villagers may sell water hyacinth by the boatload or by the weight which would then be composted at scale. This could provide income to farmers and reduce the water hyacinth problem, while giving the villagers ownership over their environment.

### 3.2.3. Promoting the Use of Bio-Pesticides

Although data about water contamination with pesticides are patchy, interviews with farmers suggest pesticides are massively overused, which then trickles down into the lake and impact the people's and local fauna's health. There should be widespread trainings about bio-pesticides and homemade solutions, which can be manufactured using easy to find ingredients.<sup>12</sup>

Most farmers are quite aware of the problems and supportive of new ideas, which is promising for the future. During our outreach campaigns, villagers were very interested in our demonstrations of homemade fertilizer, took good note of our instructions, and asked for in-depth trainings about such techniques.

### 3.2.4. Promote Good Agriculture Practices (GAP) Through a Better Linkage to Tourism Market

During our interviews with GAP farmers, farmers pointed out the lack of market for GAP products. Some efforts have been made to connect Inle GAP farmers to the Yangon market. However, the experts we met reported the difficulty and the uncertainty of such a process. We therefore suggest focusing on a closer market, which is both within reach and familiar to the farmers: the tourism sector in Southern Shan State.

The Ministry of Hotels and Tourism (MoHT), in cooperation with the tour operators, may promote products from GAP farmers to consumers, local restaurants in Southern Shan State and vegetable traders. Those restaurants may gain a competitive edge by advertising their GAP products, and demand higher prices accordingly. Marketing and awareness efforts should be done on the safety advantages of GAP products in order for customers to accept this (limited) price increase. For example, through a GAP label featured on their menus. If Hoteliers and Restaurant associations in Southern Shan State managed to promote such a scheme around Inle Lake, in Taunggyi, Kalaw, Pindaya or even Loikaw, this would create a significant and highly-

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<sup>12</sup> One technique is to make pesticide from by mixing chili, garlic, ginger, tobacco, soap with a few drops of diesel.

attractive market. This shift may be included in the local branding of the region as an ecotourism, high-quality destination. Last, but not least, restaurants do not need only tomatoes, but a wide range of fruits and vegetables: this may be an incentive for farmers to diversify their production.

### 3.2.5. Promoting Crop Diversification

One of the key issues on Inle Lake is the high dependence on tomato farming, which is virtually the only crop in the region. This has severe consequences including over production and environmental issues.

Farmers all pointed out the over-production of tomato which has been responsible for a severe price drop in the last few years. Promoting other crops would allow farmers to target other markets and align themselves on other farming calendars.

According to the experts we met, the monoculture of tomato on the same floating gardens several years in a row is responsible for the proliferation of pests and diseases. This challenge can be overcome by growing several kinds of vegetable in the same garden, and by a rotation scheme: one strip of floating garden may be farmed with tomato one year, lettuce another year, and beans another year.

Crop diversification may be supported through several actions such as development and promotion of efficient seeds and farming techniques for other crops than tomatoes. The MIID team met officials from German GIZ, who are seeking to set up an agriculture training centre on the lake. This may be a key structure to promote other crops in the future.

Work should also be done to link to new markets, either local or national. Here, Young Ambassadors would like to emphasize the role of wholesalers and brokers, who know the trends and can have very significant influence over the farmers to re-orientate their productions.

## 4. Water and Sanitation Issues on Inle Lake

There is a lack of research on the water quality of Inle Lake. Research conducted by the Inle Lake Young ambassadors with MIID included village interviews and chemical testing of the water. The results suggest that many villages do not have proper sanitation or toilet facilities and that an excessive amount of bathroom and other household wastes is disposed of directly in the lake water, resulting in the growth of harmful bacteria. The household waste pollution combined with agriculture pollution increases risk of disease and growth of the water hyacinth on the lake. Residents of the lake are increasingly aware of the danger of the water pollution but still use the lake water in ways that increase risk of illness in their households. Continuing education efforts on proper sanitation, improving the availability of toilets and other sanitation equipment appropriate for the lake and supporting incentives that encourage better practices could all improve the water quality and reduce water-borne diseases.

### 4.1. An Assessment of the Problem

Bacterial pollution of Inle Lake is not well known but the limited existing research highlights the significant water pollution including bacteria growth<sup>13</sup>. In order to better understand this issue, a team of Inle Lake Young Ambassadors, under the supervision of MIID's Technical Advisor, from November 29 to December 5, 2019, investigated customs and behaviors of local people regarding water use and water sanitation. This included visiting 12 villages, conducting in-depth interviews with 63 people, including 53 villagers, 8 village leaders, the Intha Minister Dr Tun Hlaing as well as the Chief Doctor of Nyaungshwe hospital.

All villagers interviewed (100%) replied that they disposed of general wastewater (produced by cooking, dish washing, laundry, etc.) directly into the lake. Seven village leaders described highly different sanitation situations with the best equipped village having more than half of households with a proper toilet system, while other villages reported less than little to no sanitation infrastructure (See Table 1).

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<sup>13</sup> Akaishi et al. 2006; Saw Yu May, 2007; Mar Lar Htwe, 2008

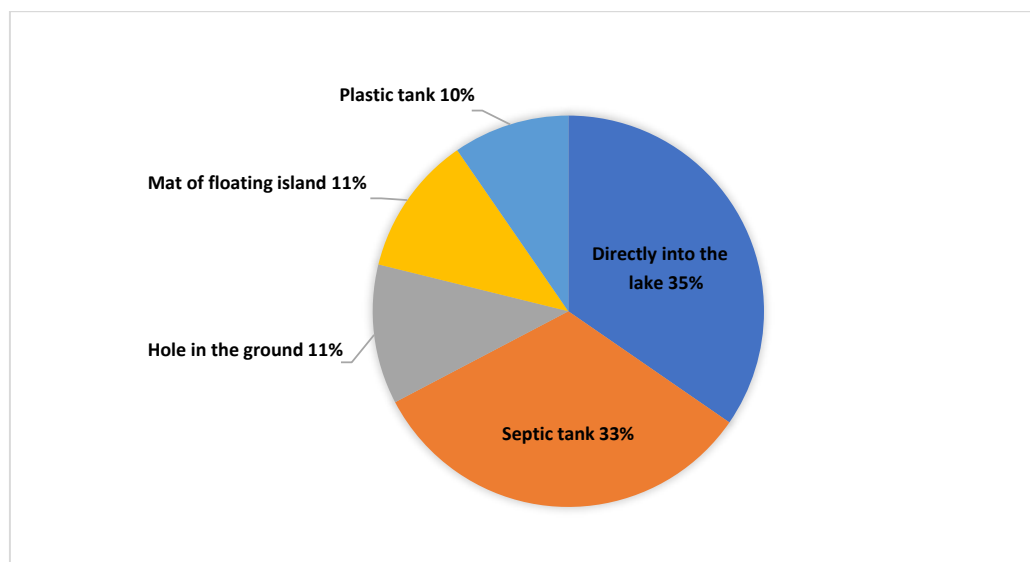
<b>Table 1</b>	
<b>Village name</b>	<b>% of houses fitted with toilet system</b>
Pwe Sar Gone	54%
Nampan	36%
Ein Htaung Gyi	19%
Tha Le Oo	14%
Shay Wa Gyi	5%
Pauk Par	2%
Kay Lar	0%

Having proper toilet systems seems related to socio-economic levels and physical setting. Well-off people are more likely to have toilets at home. Houses settled on dry land or in shallow water areas were more likely to be fitted with a proper toilet system, such as septic tanks, while stilt house owners living at the center of the lake complained that septic tanks cannot be set up in deep waters, so they discharge toilets directly into the lake.

More than one third of villagers interviewed do not have any toilet system; one third are equipped with a septic tank; 22% discharge their toilet wastes into a hole or on floating islands and 10% use a plastic septic tank. Among the people who have a septic tank, the oldest toilet system was built in 1999 and the most recent one in 2017, with systems setup in 2011 on average.

Of those without a tank, 90% stated they plan to acquire/build one, suggesting that villagers are aware of the importance of having a septic tank, and that there is a willingness to acquire one.

Figure 11: Toilet Equipment on Inle Lake



The Inle Lake Young Ambassadors investigated the origin of drinking water in the respondents' villages throughout time. In the past, 61% of villagers interviewed used to drink water from the lake and 23% from a spring. Nowadays, practices have dramatically changed with only 3% of the respondents still consume lake water; 50% drink purified water; 23% spring water, while others draw water from a well or collect rainwater.

Respondents reported that habits began to shift in 1999 and as recently as 2017, occurring in 2012 on average. According to our interviews the water was not safe: half of the people who drank it experienced stomach problems, while 38% of those consuming spring water complained of kidney issues.

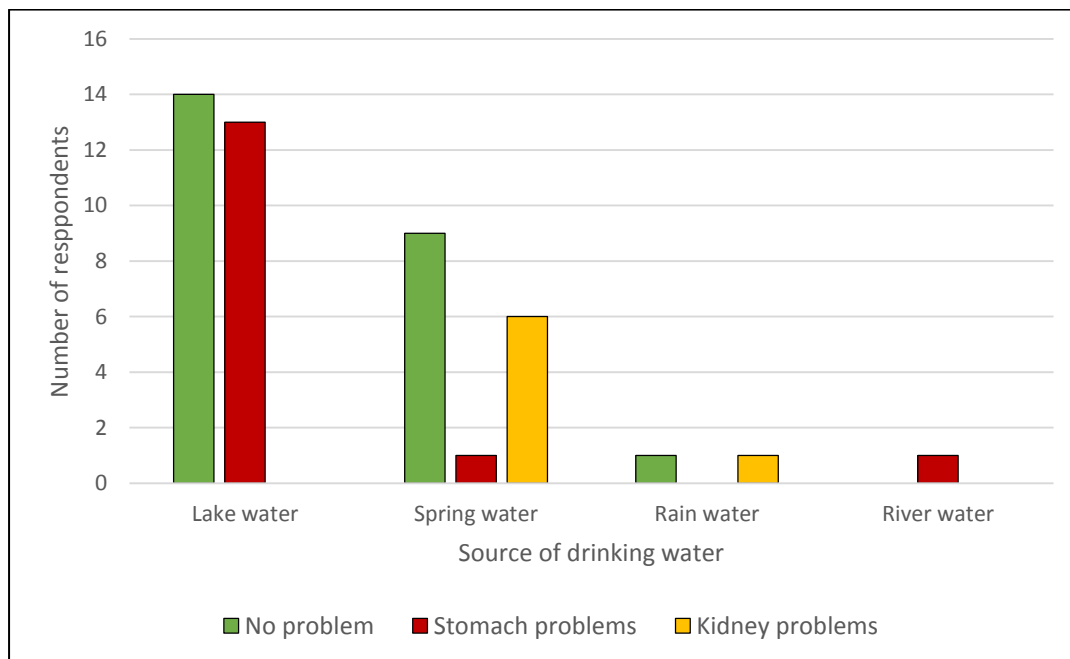
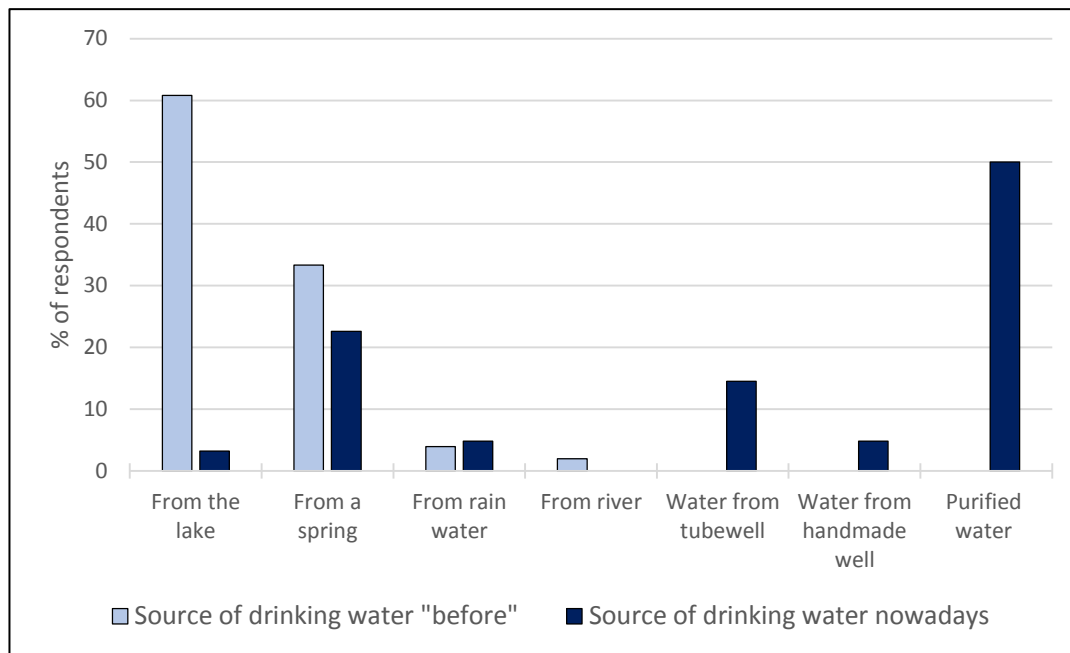


Figure 12: Water sources and health issues on Inle Lake in the years 2000.

Although most lake dwellers seem to have embraced safer habits for drinking water, they seem to be less cautious for other important water uses (figure 4). For instance, 61% of the respondents still bathe directly in the lake, usually on the steps of their houses a few meters away from their latrine.

Food preparation is also concerning. Only 3% of our interviewees drink lake water, but 12% still use it to rinse their food. With five of the seven interviewed also state experiencing stomach problems. A deeper investigation is required to verify, but there might be a causal link between both.

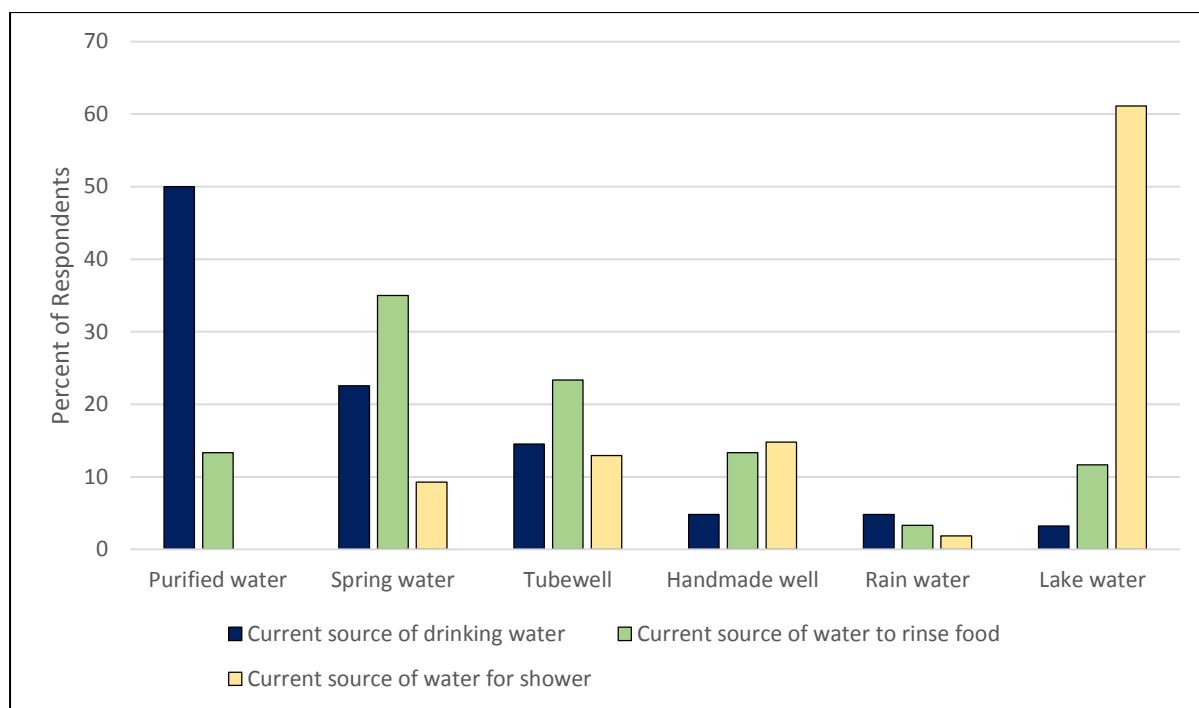


Figure 13: Water Sources for Domestic Usage.

To better understand the water quality, MIID and the Inle Lake Young Ambassadors tested for bacteria in the lake water using the U.S Environmental Protection Agency approved Colilert test produced by IDEXX Laboratories, Inc., an American multinational engaged in water testing and sold in Myanmar by the laboratory supplies provider Nanova Co., Ltd. The bacteria E. Coli is the most frequent bacteria found in human feces and is responsible for severe digestive diseases.<sup>14</sup> Unlike other surveys, we did not collect water samples from the middle of the lake, since few use it as drinking water, instead testing the water in village canals. This water is still used by significant amounts of people to clean food, wash their plates, bathe or brush their teeth. In our opinion, those daily habits are real contamination vectors.

The water sampling campaign took place on March 8, 2020 and two teams collected 20 water samples from 18 villages (Figure 11). After 24 hours, all 20 water samples (100%) tested positive for E. Coli (figure 12). This suggests a widespread, systematic contamination of Inle lake water, and raises very serious health issues. Water samples were often collected a few meters away from women bathing or from someone brushing teeth on the steps of their house.

Those habits, those oft-unconscious behaviors, may explain why water-borne diseases are still prevalent in Nyaungshwe Township. The Chief Doctor of Nyaungshwe Hospital explained to the Young Ambassadors that in 2017, diarrhea was still the leading cause of morbidity, with 1,659 cases, and dysentery was the second cause with 736 cases. The people affected cannot work or attend school for several days, which can have deep and long-lasting impacts.

<sup>14</sup> Escherichia coli (E. coli) bacteria normally live in the intestines of healthy people and animals. Most varieties of E. coli are harmless or cause relatively brief diarrhoea. But a few particularly nasty strains, such as E. coli O157:H7, can cause severe abdominal cramps, bloody diarrhoea and vomiting. See: <https://www.mayoclinic.org/diseases-conditions/e-coli/symptoms-causes/syc-20372058>



Figure 14: Map of the 18 sampling points for E. Coli, 8th March, 2020

#### 4.2. Water sanitation issues: Towards Some Solutions

Based on that assessment of the situation and on the encounters, testimonies and observations they could do on the field, the Young Ambassadors would like to suggest several potential solutions.



#### 4.2.1. Better education and information

Presently, most lake villagers fully understand that the lake water is not fit for consumption and have shifted to other sources of drinking water. However, this shift may also slow down the villagers' efforts to invest in proper toilet systems: considering that they do not consume lake water anymore, villagers do not necessarily see the necessity of investing 100,000 or 200,000 MMK (USD 67-133) to reduce the water pollution.

The Young Ambassadors suggest continuing the already-existing education efforts, but also shifting slightly their focus from drinking water to other issues. For instance, it should be made very clear that rinsing food, brushing one's teeth or bathing directly in the lake is a risky practice. Likewise, one should point out the fish contamination with potentially harmful bacteria. Finally, one may insist on the linkage between urine and feces discharge directly into the lake and the proliferation of water hyacinth. Considering that the latter is widely identified as a major issue on Inle Lake, that argument might be an efficient way to promote better water sanitation.

#### 4.2.2. The adoption of simple and innovative techniques

The efforts for introducing better water sanitation sometimes meet technical hurdles. The Young Ambassadors could observe a few simple, cheap but very efficient techniques: toilets appropriate for the lake, urea collection for agriculture and wetland-based water sanitation.

In the middle of the lake, villagers reported that water is too deep to set up septic tanks. The government should support entrepreneurs with the sale or the development of an appropriate technology for Inle Lake's wetland environment. For example, in Cambodia the social enterprise Wetland Works! has developed sanitation measure that can work in a lake or wetland environment effective for Lake Tonle Sap. This company has designed floating "Handypods", based on a very simple design, microbial biofilm and water hyacinth.<sup>15</sup> This device, which costs 100 to 150 USD per unit, may be an efficient solution for Inle Lake villages. It might be implemented quickly and at little cost if this product is introduced as a commodity that can be produced and marketed by Intha entrepreneurs.

Human and animal urine and waste is an efficient fertilizer. A program could set up a household collection scheme, transforming urine into a commodity used on the farms.<sup>16</sup> This would reduce the consumption of fertilizer and improve water sanitation, possibly providing additional income to some households. Such a program should be based on a thorough socio-economic and cultural survey.

The innovative wetland treatment system at the Inle Heritage Hospitality Vocational Training School (IHHVTC) uses several local plants to purify used water. It may be replicated in some other places of the lake, in hotels or in villages.

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<sup>15</sup> 2020, 14 February. "The HandyPod chronicles: Cambodias floating toilets two years on." Accessed March 16, 2020. [washmatters.wateraid.org/blog/the-handypod-chronicles-cambodias-floating-toilets-two-years-on](https://washmatters.wateraid.org/blog/the-handypod-chronicles-cambodias-floating-toilets-two-years-on).

<sup>16</sup> The organization WetlandWorks! Does something similar in Cambodia.



Figure 15: The 20 positive water samples were presented to U Nay Myo, Member of Pyithu Hluttaw for Nyaungshwe constituency, on 14th March 2020.

#### 4.2.3. Financial incentives and sanctions

All along their interviews, the Young Ambassadors observed the complexity of the water sanitation issue. Financial issues were recurrent in the conversations. With this in mind, the following initiatives are suggested: loans for water equipment, payment for environmental services and incentive schemes for good practices.

There should be small, low-interest loans for poorer households to use towards water supply or water sanitation system. Such loans, which could be overseen by the government, should provide a relevant flexibility, compatible with people's repayment capacities; they may also involve local authorities (village leaders or instances involving monks), providing the relevant social incitement to reimburse those loans. Entrepreneurs in the sanitation business could also setup payment by installment plans for households that cannot afford the sanitation equipment up front.

Another option would be to compensate poorer households for providing environmental services, payment which then can go towards water supply or water sanitation system. For instance, they may get a septic tank in exchange for clearing a certain amount of water hyacinth or recovering quantity of plastic pollution collected on the lake. Such a scheme may be relevant in Inle context, where some families lack cash, but not labor force.

The families who can afford a septic tank may be invited to acquire one in a certain timeframe; afterwards, the authorities may set up a sanction scheme, in which a household should pay a fine every month as long as they do not have a proper water sanitation system.

The Young Ambassadors hope that the implementation of the Inle Lake Management Authority (ILMA) will pave the way to a close monitoring of the water and sanitation issue and to the promotion of innovative and efficient solutions. For more details about water supply, water sanitation, challenges and recommendations, MIID produced a 36-page report about those topics in 2012 (IID, 2012). The latter can be provided upon request.

## 5. Solid waste management

Solid waste issue has been increasing in Inle Lake region in the last few years. There are some positive local initiatives, but a comprehensive, integrated system is yet to be designed. The Inle Lake Young Ambassadors would therefore recommend decreasing the production of waste, through a ban over certain categories of goods and the promotion of more sustainable alternatives. They also suggest improving the collection and recycling scheme, simultaneously based on local communities and on a regional strategy.

### 5.1. An assessment of the problem

Solid waste management in the Inle Lake region has been poorly documented in scientific literature.<sup>17</sup> However, through interviews and trips to the field, we have found the issue to be clearly identified by local lake dwellers, CSOs and NGOs. Poor waste management has several negative consequences in the region: solid waste is a potential danger for human health and local fauna, it is also a visual nuisance which reduces the visual appeal of the region. Besides the potential consequences on the tourism, several villagers emphasized that this also harms the very Intha identity. The proliferation of solid waste is not the only problem. Current disposal habits are also problematic such as household-scale burning of solid waste represent a health threat for neighbouring populations.



Figure 16: Waste discarded in Mingalar Zay canal in Nyaungshwe.

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<sup>17</sup> Buijendijk, Harald, and Kristina Tschunkert. "Hotel industry expansion and sustainable development: A case study of Inle Lake, Myanmar." *Research in Hospitality Management* 6, no. 1 (2016): 9-23.



Figure 17: Waste dump in marsh lands west of Inle Lake.

Numerous CSOs, INGOs and international organizations have been mobilized for several years to address waste issues. Despite many commendable efforts, an overall solution is yet to be found and implemented. As of March 2020, the situation in Nyaungshwe Township is the following:

Since February 2019, trash from Nyaungshwe town and its immediate surroundings have been collected by locally-based company Inle Rose, which then sorts and recycles some of it. The intervention of that company has resulted in a visible improvement of the situation in the town.



Figure 18: The Young Ambassadors visit Inle Rose facilities, October 2019

In the rest of the township, waste management shows its limits. In some villages, local Civil Society Organizations (CSOs) lead waste collection campaigns. However positive, those initiatives are few, irregular and insufficient to stop the litter problem.

## 5.2. Solid waste management: towards some solutions?

Based on this assessment, on their own experience and conversations with local stakeholders and experts, the Inle Lake Young Ambassadors and MIID recommend a few useful steps to keeping Inle Lake clean.

### 5.2.1. Waste reduction

One of the first steps to solve the solid waste issue would be to reduce waste production and encourage recycle and reusable goods. Kalaw township was selected in Shan State for the program “One State, One Township”, which purpose is to make select townships plastic-free. Nyaungshwe township authorities can partner with CSOs and engage Inle region in a similar campaign, learning from the Kalaw experience, challenges and solutions. Local authorities might also draw inspirations from neighbouring countries, such as India or Bangladesh, which have either banned one-use plastic bags, required customers to pay for them (not be provided for free by default) or put taxes on them. Exposure trips and exchange programmes might support such a project.

During their outreach activities, the Young Ambassadors handed out hundreds of reusable cotton bags and refillable water bottles to the villagers. Such practices and products should be promoted. The ultimate goal would be to transform those products into daily commodities, made locally and for profit by local artisans.

The tourism sector can be a prime contributor to those efforts. Some promising efforts have already been engaged by some tour-operators and hotels. Considering the wide availability and the affordability of purified water, the hoteliers association might incite hoteliers, tour guides and boat drivers to provide plastic bottles only on request, and to develop on the lake a network of safe and trusted refilling points for reusable bottles, featuring clear and reliable information to visitors.

### 5.2.2. Improved waste collection and processing

One of the main issues in terms of waste collection is accessibility:

- For many lake dwellers, bringing their waste to dry land requires an effort. The Young Ambassadors would suggest setting up a specialized boat service, with *ad hoc* boats, fitted with the proper equipment, servicing lake villages on a regular basis.
- An improved waste collection system may also base on the five-day market: at each of those markets, CSOs or private companies may hold a waste collection booth, at which market-goers may redeem their waste for a certain amount of cash, based on the quantity and the nature of waste provided.
- For mountain villages, distance acts as a potent deterrent, both for villagers and for potential collection company. We would suggest providing each village a metal skip, in which local people may dump their waste; the skip would then be collected by a truck on a regular basis, for instance every week, in exchange of a new, empty skip. We are aware of the price of such an equipment; locally-made alternatives might be considered.

Around Nyaungshwe town, waste is collected and sorted out by Inle Rose company. Recyclable waste is then sold in Mandalay; this source of income covers a significant part of Inle Rose’s operation costs. Our suggestion would be to shift this financial incentive up the value chain, up to the village scale, in order to provide an economic incentive to the villagers to collect, sort out and recycle waste. According to Young Ambassadors’ interviews and exposure trips, it is important that waste be clearly framed as a commodity, a resource that people can trade for additional income. One may imagine information sessions featuring several sections:

- Presentation of waste management challenges and risks
- Presentation of Inle Rose activities
- Participatory calculation of the amount of waste produced by the village community
- Participatory calculation of the income that might be derived from it by selling recyclables.

- Purchase of a first batch of waste by Inle Rose in order to give a very short-term illustration of the benefits for the community
- Discussion of longer-term collaboration between Inle Rose and the community.

For the moment, one of the limitations of Inle Rose operations is that recycling facilities are located in Central Myanmar. Transportation is therefore a major operational cost. MIID would suggest encouraging the creation of modern recycling facilities in Southern Shan State. French company Veolia, a leading player of drinking water networks and waste processing solutions, is reportedly interested investing in Southern Shan State. MIID would suggest opting for an integrated, regional approach: instead of holding discussions between Veolia and individual townships, relevant authorities may sign a waste management contract for the whole Inle Lake watershed (741,000 inhabitants) or even for the whole Taunggyi district (1,7 million inhabitants). The intervention of such a player may not jeopardize the healthy and dynamic fabric of CSOs and social enterprises currently involved in waste management. We may imagine a tiered system, in which village communities would collect and sort out waste; Inle Rose would buy it, transport it and sell it back to a private recycling company in Southern Shan State; the latter would then recycle and valorise waste. Such a system would allow benefits for all stakeholders and would position Southern Shan State as a leading region in Myanmar for waste management.

Improving waste management will most probably involve a spatial scale-up, and a whole integrated approach, from the village level to the whole watershed level, or even beyond. In that process, Inle Lake Management Authority appears as a potential key player, able to articulate several spatial levels and several categories of stakeholders.

## References

- Akaishi F. et al. (2006). Surface water quality and information about the environment surrounding Inle Lake in Myanmar. *Limnology*, 7: 57-62.
- FAO (Food and Agriculture Organization). (2003). *Myanmar aquaculture and inland fisheries*, RAP Publication 2003/18. Bangkok: FAO.
- Furuichi T. (2008). *Catchment Processes and Sedimentation in Lake Inle, Southern Shan State, Myanmar*. Canberra: Australian National University.
- Furuichi T. (2009). Land-use change in the Lake Inle catchment. *Kyoto working papers on area studies*, 26.
- Institute for International Development (IID). (2012). *Inlay lake conservation project : a plan for the future*. Yangon: IID.
- Kano Y. et al. (2016). A dataset of fishes in and around Inle Lake, an ancient lake of Myanmar, with DNA barcoding, photo images and CT/3D models. *Biodiversity Data Journal*, 4. <https://doi.org/10.3897/BDJ.4.e10539>
- Karki S. et al. (2018). Impact of land use land cover change on ecosystem services: a comparative analysis on observed data and people's perception in Inle Lake, Myanmar. *Environmental Systems Research* 7:25. <https://doi.org/10.1186/s40068-018-0128-7>
- Mar Lar Htwe (2008). *Analysis of water pollution in freshwater Inle Lake based on eutrophication*. Unpublished PhD thesis in zoology. Yangon University.
- Michalon M. (2014). *The gardener and the fisherman in Globalization: Inle Lake (Myanmar), a region under transition*. Mphil thesis in geography. Lyon 2 University. <https://doi.org/10.13140/2.1.4600.6083>
- Michalon M. et al. (2019). Accelerated degradation of Lake Inle (Myanmar): A baseline study for environmentalists and developers. *Land degradation & development* 30/8: 928-941. <https://doi.org/10.1002/ldr.3279>
- Ministry of Environmental Conservation and Forestry (MoECAF). (2014). *Inle Lake long term restoration and conservation plan*. Nay Pyi Taw: MoECAF.
- Myanmar Institute for Integrated Development (MIID). (2014). *Destination Management Plan for the Inlay Lake Region, 2014-2019*. Nay Pyi Taw: MoHT.
- Okamoto I. (2012). Coping and adaptation against decreasing fish resource: case study of fishermen in Lake Inle, Myanmar. *Institute of Developing Economies (IDE) discussion paper*, 329.
- Qin Niu et al. 2015: Slash-and-char: An ancient agricultural technique holds new promise for management of soils contaminated by Cd, Pb and Zn. *Environmental Pollution* 205: 333-339. <https://doi.org/10.1016/j.envpol.2015.06.017>
- Saw Yu May (2007). *Changes of water quality and water surface area in Inle Lake : Facts and perception*. Unpublished PhD thesis in Geography, Yangon University.
- Seint Seint Win et al. (2018). Assessment on fishery sustainability in Inle wetland, Nyaung Shwe township, southern Shan state. *International Journal of Avian & Wildlife Biology*, 3/5: 345-350. <https://doi.org/10.15406/ijawb.2018.03.00118>

Yuasa et al. (2019). Current Water Quality of Inle Lake in Myanmar; A Potential Threat to the Lake Environment. Paper for International Alliance for Sustainable Urbanization and Regeneration Conference. 9 p.